STUDIES ON COMPOSTING OF SOLID WASTES FROM A VEGETABLE TANNERY

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in partial fulfilment of the requirements
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by

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CERTIFICATE

This is to certify that the present work has been done under my supervision and the work has not been submitted elsewhere for a degree.

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SYNOPSIS

The study describes the use of two solid waste materials from a vegetable tannery for composting purposes. Spent tannery bark and waste fleshy material from hides are mixed in various proportions and composted aerobically and anaerobically. The results indicated that these material could be converted into useful fertilizer products. The carbon-nitrogen ratio of around 28 gave good rate of decomposition both in aerobic and anaerobic methods. The final product had 1.2% nitrogen and 0.13% phospherous (both on dry weight basis) which makes it a good fertilizer.

1. INTRODUCTION

Kanpur is one of the major industrial cities of India wherein are located about 45 tanneries, more than ten textile mills, two jute mills and a number of chemical and metallurgical industries.

The major wastes coming out of a tannery are the liquid wastes comprising of spent tan-liquor, liming, deliming, and soaking wastes while the solid wastes consist of fleshings from the skins and spent waste of vegitable matter like bark of babul tree and other materials that are rich in tannin. Considerable amount of work is done by Prabhakara Rao and Dasmurkar (1), Thabarvaj etal (2), on the disposal of liquid wastes. In some of the tanneries the fleshy material is dumped out to decompose in the open yard inviting a number of vultures and causing nuisance in the neighbourhood, while some of the establishments sell it out to some farmers who throw the fleshy materials on fields to rot for fertilizer purposes. Most of the spent tannery solid waste is used as fuel. No information was available regarding any composting studies of these solid wastes and it was felt that a systematic study of composting with these two materials would yeild valuable information for conversion of a waste product into useful fertilizer.

Composting is a biological process which results in the ~~[illegible]~~ production of stable humus from decomposable organic matter. It has two aspects to deal with, one is the public health aspect and other is the fertilizer aspect of it.

1.2 Importance of Composting Sanitary Aspect

Harold B. Gottas (4) states that there are two important health aspects associated with the disposal and utilization of wastes. One is the high incidence of illness and deaths from diseases which result from insanitary disposal and utilization of wastes. The other is the improved nutrition, an important factor in the prevention of disease, which can be obtained when the wastes are returned to agricultural lands to provide plant nutrients.

Scott (4) has demonstrated in experimental composting studies in China, that the causative organisms of many diseases are destroyed by aerobic composting if temperatures in the thermophilic range are maintained for a sufficient time and all of the material is subjected to these temperatures.

According to a survey carried out (5) the Delhi infectious haepatitis epidemic of 1955-56 occured when the Jamuna water polluted by Najafgarh drainage, was pumped into the water plant and was not adequately treated. Thus disposal of any waste, either solid or liquid without a proper treatment is bound to pose a serious public health problem.

Considerable amount of work has been done in the recent years to treat the solid wastes from several industries. Ervin Hindrin and G.H.Dunstan (6) in their study on anaerobic digestion of potato processing wastes showed that mixtures of potato chip wastes in raw sludge containing as high as 50% of potato chip wastes can be satisfactorily treated. Vollbrecht.H (7) conducted studies towards the anaerobic decomposition of solid wastes from meat packing industries.

Modern composting first suggested by Sir Albert Howard (8) and his associates from studies in India and carried forward thereby Acharya and Subramaniam (9) has been investigated extensively by Scott (4), Gottas and by many others in different parts of the world.

1.3 Importance of composting, Agricultural aspects;

Willcox, Comber (10) stated that the reason why India cannot grow enough food for her people is primarily because her crop yield per acre are perhaps the lowest in the world. There are many reasons for this including the lack of proper application of scientific methods, draughts, infertile soil. Every soil can be made fertile by proper application of fertilisers and manures.

Humus from night soil, garbage, and other organic wastes has properties valuable to vegetation. The wastes contain nitrogen, phospherous and potash which are vital for the continuing fertility of the soils. In addition tthey contain trace elements known to be essential for optimum plant growths(11).

It is also believed by many authorities that the susceptibility of crops to parasites and infectious desieses is increased by a shortage of the trace elements. Thus humus may lessom the frequency of plant desiesesin in crops(12).

1.4 AIM :

It is proposed to study the aerobic and anaerobic decomposition of the solid waste materials from a vegetable tannery to find out the optimum ratio for the initial mixing of the wastes to obtaine a stable end product.

1.5 Scope :

The work is limited to only two of the major wastes from a vegetable tannery, i.e., fleshings and spent vegetable wastes. The initial carbon and nitogen ratios (C/N) and moisture content throughout the composting operations are controlled and other parameters are studied.

The following parameters have been selected in the study.

1. C/N ratio :

As pointed out in the next chapter, the rate of decomposition of organic matter is affected by the initial amounts of carbon and nitrogen. Thus C/N ratio has been conveniently adopted by many research workers to study the rate of degradation.

2. Temperature :

Temperature is a controlling factor perticularly in the aerobic composting process.

3. Percentage Nitrogen :

Reclamation or conservation of the nutrient and fertilizer value of the waste is one of the most important purposes of composting organic wastes. Thus studying the loss of nitrogen in various forms in the two processes is important.

4. pH :

pH plays a very important role in the conservation and reclamation of nitrogen perticularly in the anaerobic composting process.

5. Physical Observations : Colour, odour and structure :

These are important in judging the completion of the composting process.

In addition to these, the phosphate content of the final product is determined. The pertinent literature on the process of composting is given in the following chapter.

2. Literature Review

2.1 History of Composting

There is a reason to believe that early in the development of agriculture man learned to use leaf mold, animal manure, decayed fish and other decomposed organic matter in husbanding his crops (13).

The first patented process in the field of composting was developed by Giovanni Beccari (14) of Florence, Italy in 1922. It combined an initial anaerobic fermentation with a final stage in which decomposition proceeds under partial aerobic conditions. A modification of Beccari process known as the Verdier process provided for the recirculation of gases of drainage liquors. A further modification of the process was made ~~by~~ in 1931 by Jean Bordas who sought to eliminate the anaerobic stage.

According to Kawata (15) perhaps the ~~a~~ first significant development in composting as an engineered process took place in India in 1925. At that time Sir Albert Howard at Indore in collaboration with others systematised the procedure by which farmers and gardeners had for many centuries produced humus for use on the soil. This process is known as Indore process which is essentially an aerobic composting process.

Acharya (13) working for the Indian Council of Agricultural Research reported the development of anaerobic composting method which came to be known as Bangalore process.

In January 1946 the Indiana Brewers Association instituted a research program at Purdue University for the purpose of investigating possible methods of disposal of spent grains press and spent hops. The observations of Weber and Nicol (16) of Purdue University indicated that compost made from heaped rotted spent hops made a good fertilizer, high in

humus matter. Hop residue on the average contained nitrogen 0.56 to 0.87% phosphoric anhydride 0.15% and potash 0.02%. Niles Jr., (16) worked on the problem of aerobic composting of spent hops and concluded that 55 to 70% of the total solids, approximately 50% nitrogen were lost by composting, however spent hops could be composted without producing odour nuisance.

In 1949 a process (3) patented in the united States was introduced in which shredded organic matter was put in a fully enclosed semi-mechanised digester under aerobic conditions by intermittently dropping the material from one level to another to produce composting in 28 days.

Studies were made in 1963 by Karel Janski (17) on the method of purification of tannery sewage and the influence of its components, amounts and influence on the receiving stream. He concluded that priliminary screening of coarse solids gives a product containing 8 to 10% of organic nitrogen and 15 to 20% of ash, which can be composted with lime to get an useful fertiliser.

In 1966 Tranina and Veresova (18) composted anaerobically sawdust supplemented with horse manure. At the end of the composting period, they found a reduction of 50% in the carbon content and the nitrogen was reduced by 40%. The composts were used as fertilizer for potatoes and oats.

In recent years considerable amount of work has been done on composting industrial wastes. Scott (4) conducted several experiments on aerobic composting, in China and studied the role of temperature in the elimination of pathogenic organisms. Hindrin and Dunstan (6) observed the anaerobic digestion of potato processing wastes and showed that raw sludge containing 50% of potato chip wastes could be satisfactorily treated.

Several other people have worked in the recent years in the field of composting of meat packing wastes (7), town wastes (13), garbage (9) and other types of solid wastes.

Several improvements have also been made in the recent years on the techniques of composting waste material on a large scale. In 1967 Lawrence E.Redman (26) designed an efficient and economical apparatus for continously producing soil nutrients (humus) from waste products. On a slow moving conveyer, salvagable items were removed by hand and metallic objects by a rotating magnetic drum. Then the wastes were ground wetted with warm water and mixed well in an inclined rotating drum having internal baffles. The material was then delivered to the digester vat where it was composted.

2.2 Principles of Composting :

According to Gottas (3) generally speaking there are two composting processes namely, (a) aerobic decomposition and stabilisation and (b) anaerobic fermentation. In these processes bacteria, fungi, moulds and other saprophytic organisms feed upon organic materials such as vegetable matter, animal manure, night-soil and other organic refuses and convert the wastes to a more stable form. The end product in composting is termed as humus.

When organic material is decomposed in the presence of oxygen the process is called " aerobic ". Here living organisms which utilize oxygen

CYCLE OF NITROGEN AND CARBON II. ANAEROBIC DECOMPOSITION

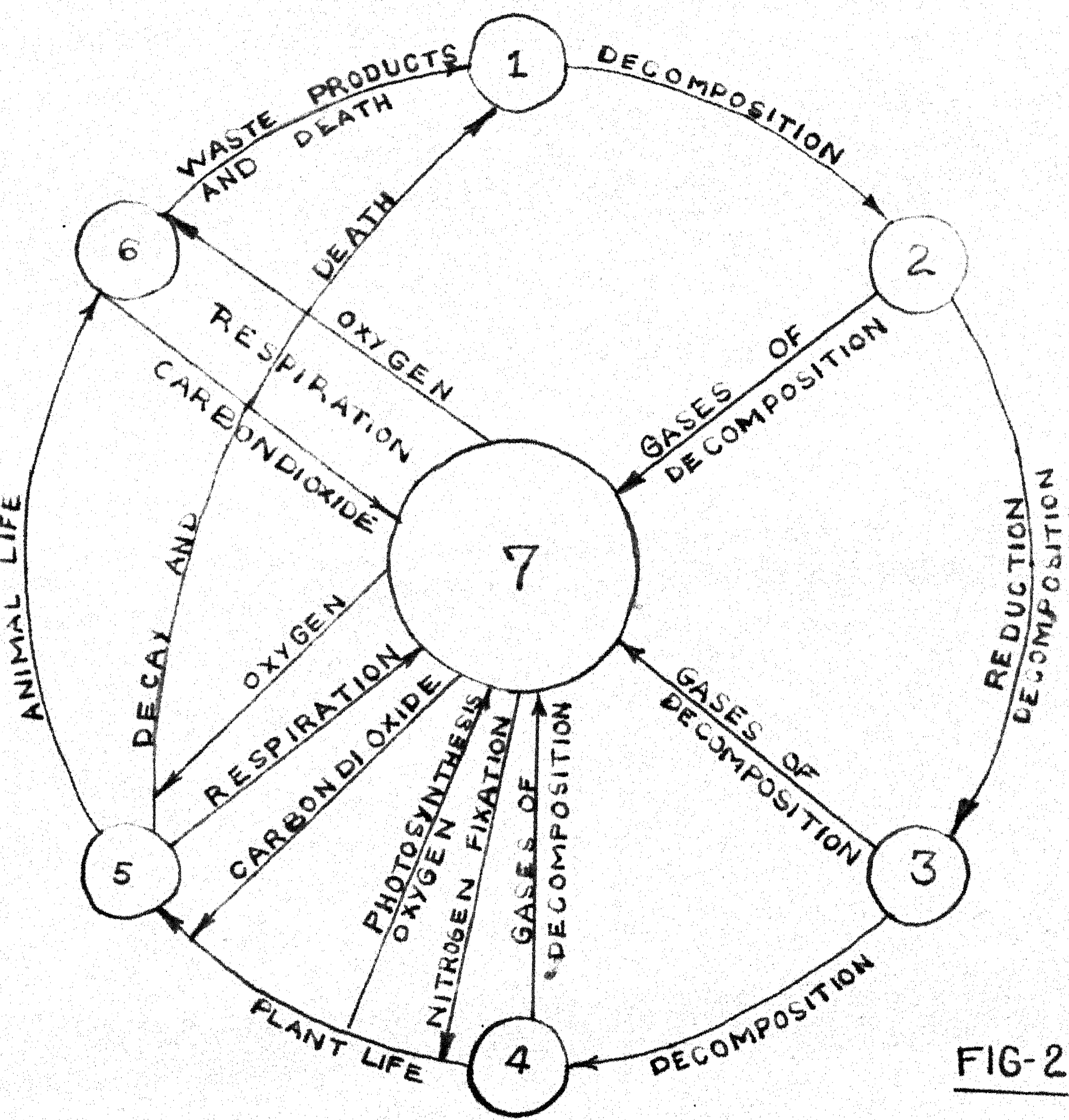

FIG-2

1. DEAD ORGANIC MATTER CONTAINING ORGANISMS, AND NITROGENOUS AND CARBONAC-EOUS MATTER
2. INITIAL PRODUCTS OF DECOMPOSITION. ORGANIC ACIDS, ACID CARBONATES AND CARBONDIOXIDE.
3. INTERMEDIATE PRODUCTS OF DECOMPOSITION AMMONIA, NITROGEN, HUMUS, CARBONDIOXIDE AND METHANE
4. FINAL PRODUCTS OF DECOM-POSITION – AMMONIA, NITROGEN HUMUS, CARBONDIOXIDE AND METHANE.
5. LIVING PLANT MATTER PROTEINS, CARBOHYDRATES, FATS.
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7. RESERVOIR OF OXYGEN NITROGEN CARBONDIOXIDE IN AIR AND WATER.

feed upon the organic matter and develop cell protoplasm from the nitrogen phosphorous, some of the carbon, and other required nutrients. Sinse carbon serves both as a source of energy and as an element in the self protoplasm, much more carbon than nitrogen is needed (3). If the excess of carbon over nitrogen in organic materials being decomposed is too great, biological activity diminishes and several cycles of organisms may be required to burn up most of the carbon.

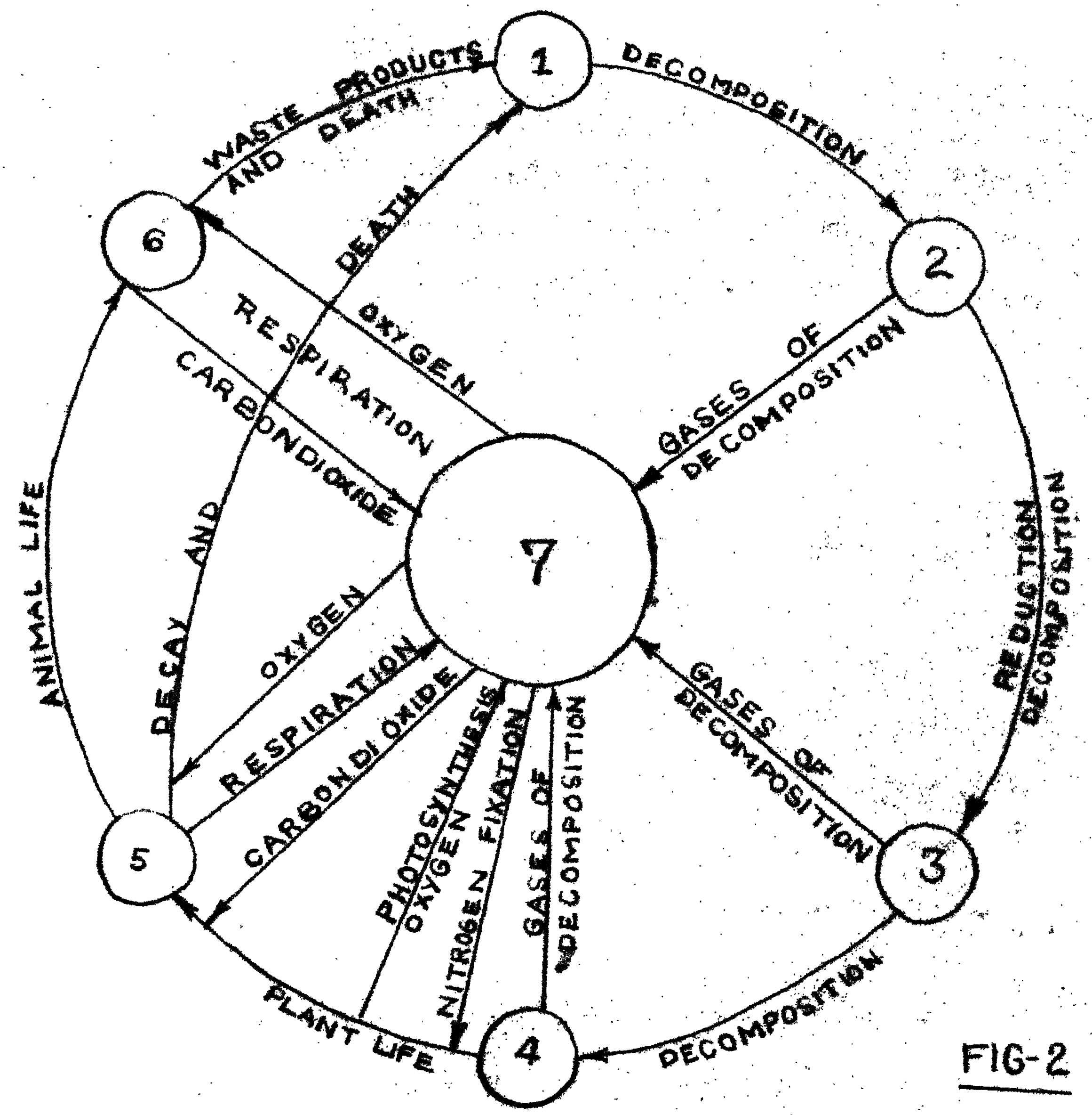
A great deal of energy is released in the form of heat in the oxydation of carbon to carbon dioxide. Thus the temperature of the material during the decomposition under proper insulations will rise to over 70°C. Oxidation at thermophilic temperatures takes place more rapidly than at mesophilic temperatures and hence a shorter time required for stabilization.

Aerobic decomposition can be accomplished in silo-digesters, pits, bins, stacks or piles, if adequate aeration is provided by turning the material at intervals or adopting other techniques for adding necessary oxygen to maintain the aerobic conditions (19).

Anaerobic living organisms in metabolizing nutrients break down the organic componds by a process of reduction. As in aerobic process the organisms use nitrogen, phospherous and other nutrients in developing cell protoplasms, but reduce the organic matter to organic acids and ammonia. The carbon from the organic compounds which is not utilized in the cell protein is liberated mainly in the reduced form of methane. A small portion of carbon may also be respired as carbon dioxide.

Since anaerobic destruction of organic matter is a reduction process the final product, humus is subjected to some aerobic oxidation when put on the soil. This oxidation is minor, takes place rapidly and is of no consequence in the utilization of the material on the soil.

CYCLE OF NITROGEN AND CARBON IN ANAEROBIC DECOMPOSITION



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The most important factors in composting operations which can be briefly described are (a) carbon-nitrogen relationship (b) moisture content (c) temperature (d) pH (e) blending or proportioning of wastes (f) aeration (g) use of inocula (h) testing and judging the condition of compost (i) economic aspects of composting (3).

Living organisms utilise about 30 parts of carbon for each part of nitrogen, thus an initial carbon-nitrogen ratio (C/N) of 30 would seem to be most favourable for rapid composting and this would provide some nitrogen in an immediately available form in the finished compost. However some research workers have reported optimum values from 26 to 30. (3)

In aerobic composting a high moisture content should be avoided because water displaces air from the interstices between the particles and thereby gives rise to anaerobic conditions. On the other hand, a low moisture content deprives the organisms of the water needed for their metabolism and consequently inhibits their activity. If anaerobic composting is practised, the maximum moisture content is not as important since oxygen maintainence is not a factor. Acharya (13) suggests an optimum moisture content of 45 to 50% for aerobic and from 80 to over 90% for good anaerobic conditions.

Proper temperature is a very important factor perticularly in the aerobic composting process. Decomposition proceeds much more rapidly in the thermophilic temperature range. The optimum temperature range is 50° to 70° C, around 60°C usually being the most satisfactory. In some instances compost operators have avoided prolonged high temperatures in the anaerobic conditions because the nitrogen loss tends to be greater at high temperatures owing to the vapourization of ammonia. (3). But high temperatures are essential for the destruction of pathogenic organisms and undesirable weedseeds.

So any small nitrogen loss due to high temperatures is outweighed by the advantages of destroying pathogenic organisms and weed seeds.

The initial pH of most of the compostable material is usually between 5 and 7, unless the waste contains ash or other highly alkaline or acidic materials. When the initial pH is between 6 and 7, the pH of the composting material will usually drop a little during the first two or three days of aerobic composting owing to the formation of acids. If the initial pH is 5 or 5.5 there will be little change during this period. After two to four days the pH usually begins to rise and will level offat between 8 and 9 towards the end of the processes. The control of pH in composting is a seldom a problem requiring attention if the material is kept aerobic, but large amounts of organic acids are produced during the anaerobic composting. The alkaline substances present in the compost material will act as a buffer and keep the pH from becoming too low, however, the addition of these alkaline substances is rarely necessary and in fact, may do more harm than good because the loss of nitrogen by the evolution of ammonia as a gas will be greater at the higher pH. Since the optimum pH for most of the organisms is around 6.5 and 7.5, it would probably be beneficial if the pH could be maintained in that range.

One of the most important purpose of composting organic waste is the reclamation or conservation of the nitrogen content which plays the major role in the final fertilizer value (3,9,13). Nitrogen may be lost by leaching, but the major loss comes from the escape of ammonia or other volatile nitrogenous gases from the compost materials to the atmosphere. Ammonia escapes as ammonium hydroxide increasingly readily as the pH rises above 8.0 . In the later stages of composting the pH may rise to between 8 and 9. At this stage it may be necessary to control the pH.

As mentioned earlier, there are many tests and checks by which the various aspects of the composting process and the condition of the compost may be judged. From the point of view of the over all operation and the final product, there are three groups of tests which are suggested by Gottas (3). They are (a) tests for the sanitary quality of the operation and the finished product, that is, pathogen destruction, absence of flies and odours (b) tests for the fertilizer or agricultural value i.e., the amount of nitrogen, phospherous, potash and other nutrients (c) economic tests i.e., whether the total cost of producing the compost is less than its value as fertilizer plus the cost of disposal by other means such as incemeration or landfill.

2.3 Soil and Agricultural Chemistry

Willcox and Comber (10) state that crops are primarily to provide protein, fat and carbohydrates. In this connection, nitrogen, phospherous and potassium are the three elements which are most commonly added to the fertilizers. Calcium and magnesium have also to be considered as nutritional elements and there are number of others also.

Nitrogen is generally taken up by plants from the nitrates present in soil. The nitrogen available in soils come from organic matter incorporated in the soil as such or from the organic matter formed by the growth of certain bacteria which take up nitrogen from atmosphere with the formation of proteins in their bodies. Now with the help of nitrobacter and nitrosomonous they reach the stage of nitrates.

Natural losses of soil nitrogen take place in the following ways(11).

1. Denitrification - Under anaerobic conditions for want of oxygen by bacteria a large amount of nitrate is converted into nitrogen and lost to air.

2. Loss by drainage: This is one of the most serious losses.

Soil phospherous:

The original soil phospherous compounds will mainly be minerals such as appatite (11), but there will always be some phospherous in the organic matter that is incorporated into the natural making of the soil. the actual percentage of phospherous in soils vary a lot .

Phospherous present as phosphates are not like nitrates, removed in the drainage water. These phosphates may form insoluble phosphates with certain soil bases. Thus there is a point to be noticed concerning the availlibility to plants. the fact that phosphate is precipitated or held in some way in the solid phase may mean that much of it may not be positionally accessible to the root hairs of the plants.

Soil Pottassium:

The original potassium compounds will be such minerals as orthoclase felsper etc.. Heavy clay soils also may contain 1% or more of potassium. There is no data availble on the natural losses of potassium in the soil.

3. MATERIALS AND METHODS

The flesh matter which contributes mainly towards the total nitrogen and the spent waste of bark which contributes towards the carbon were mixed well in known proportions and were composted aerobically and anaerobically under controlled moisture content. For a better understanding of the problem, the vegetable tanning process is briefly described in the following section.

3.1 Tanning Process and their Wastes :

3.1.1 Soaking :

Raw hides as they arrive at the factory contain large amounts of salt used as a preservative. The salted hides are soaked in vats for 24 hours, to remove the salt, dirt, and to soften the skins.

3.1.2 Liming :

Salted hides are transferred into vats containing slaked lime and are allowed to remain for a period ranging from 24 to 48 hours. This process is meant for swelling the skin and for loosening the hairs. Sodium sulphite is also added to the lime vats to hasten the above process.

3.1.3 Unhairing and Fleshing :

After liming, the hairs and flesh are removed manually from hides. Fleshing operation gives rise to a waste which is more or less continous and contains fatty and fleshy particles. These flesh and hairs are usually removed manually from the hides using large double edged knives.

3.1.4 Deliming :

After the removing of hair and flesh the hides are soaked in water for 12 hours for deliming purposes.

3.1.5 Vegetable Tanning :

Tannins are a group of organic compounds widely distributed in plants, abundent in the bark but present in leaves (tea etc.) and unriped fruits(1). Tannins are bitter with astringent properties and they make the wood free from the attack of parasytic fungi and insects. For this same purpose they are used in the manufacture of leather. Tannins are also used in medicine and manufacturing of ink because it turns into blue black with iron salts. The bark of Acacia Arabica* or similar material is used for preparing tan liquor by extraction. The hides after deliming are soaked in this tan liquor for 3 to 4 days.

3.1.6 Dying and Finishing :

Now the hides are dyed and given the finishing touches.

3.2 Blending or Proportioning of Wastes :

In order to make a systematic study of the aerobic and anaerobic decomposition of solid waste materials from a vegetable tannery, a small such tannery (G.T.Tanneries, Kalianpur, Kanpur) processing about 100 hides per day was chosen.

It was decided to run three sets in both aerobic and anaerobic decompositions. The first set material having a C/N ratio between 20 and 25, in the second set material having having C/N ratio between 26

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* Acacia Arabica - gum tree; Babul(Hindi); Torua Kadam(assamese); Babla (Bengali); Kaloabava(Gujarathi) Kari Jali(Kannada); Karuvelam(Malayalam & Tamil); Babhul(Marathi); Baburi(Oriya); Kikar(Punjabi); Nalla Tumma (Telugu).

and 32 and in the third set material having a C/N ratio between 33 and 40 were composted. As explained in the previous chapter, majority of the research workers (4,27,28) have reported optimum C/N ratios from 26 to 31. However, several research workers like Acharya(3), Scott(4) have conducted several experiments on composting and have suggested that active composting can be carried out with C/N ratio in the range of 20 to 40. The above three sets of C/N ratios fall within this range and hence were chosen for the investigations.

To arrive at the proportions in which the ingridients were to be mixed, the spent waste of bark and flesh were separately analyzed for total carbon, total nirogen, moisture, [redacted] [redacted] and B.O.D. (Refer Table 4) Taking into account the values got in the above experiments, it was decided to mix the bark and flesh in the ratios of (by volume) 7:1, 6:1, 5:1 to get the C/N ratios of 36, 28 and 21 respectively.

To achieve the above desired C/N ratios trial runs were conducted in the Laboratory. The two materials along with the seed were mixed well in the said proportions and their C/N contents were checked.

3.3 Preparation of the Materials for the Experiments :

The spent wastes of bark were available in the pulverised form as they are crushed well before they are fed in the process of extraction of tannin. The flesh pieces are peeled off from the hides using about a metre long knives which are sharpened on both the edges. These pieces were on the average about 2" wide, 4" long and about ½" thick.

To have a homogenous mixture in the composting process, it was decided to cut these flesh pieces into smaller ones of size about 1" wide, 1" long and ¼" thick. This was done by using a well sharpened knife (1.5' long).

The seed for the compost was the earth collected from the fields near the tannery. To characterize the seed, the B.O.D was also determined.

The above ingredients were mixed well in the said proportions. The mixing was done by overturning the material several times using a shovel.

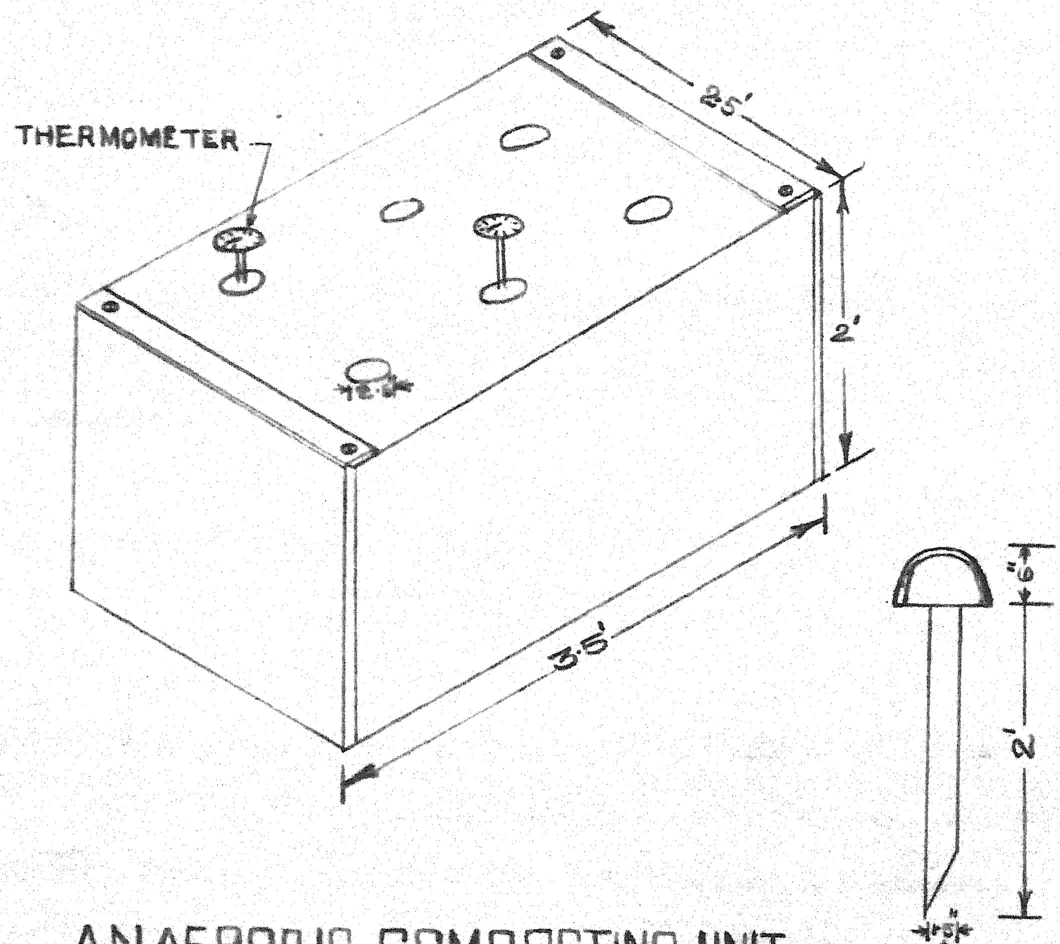
3.4 Design of Composting Units :

3.4.1 Anaerobic Composting :

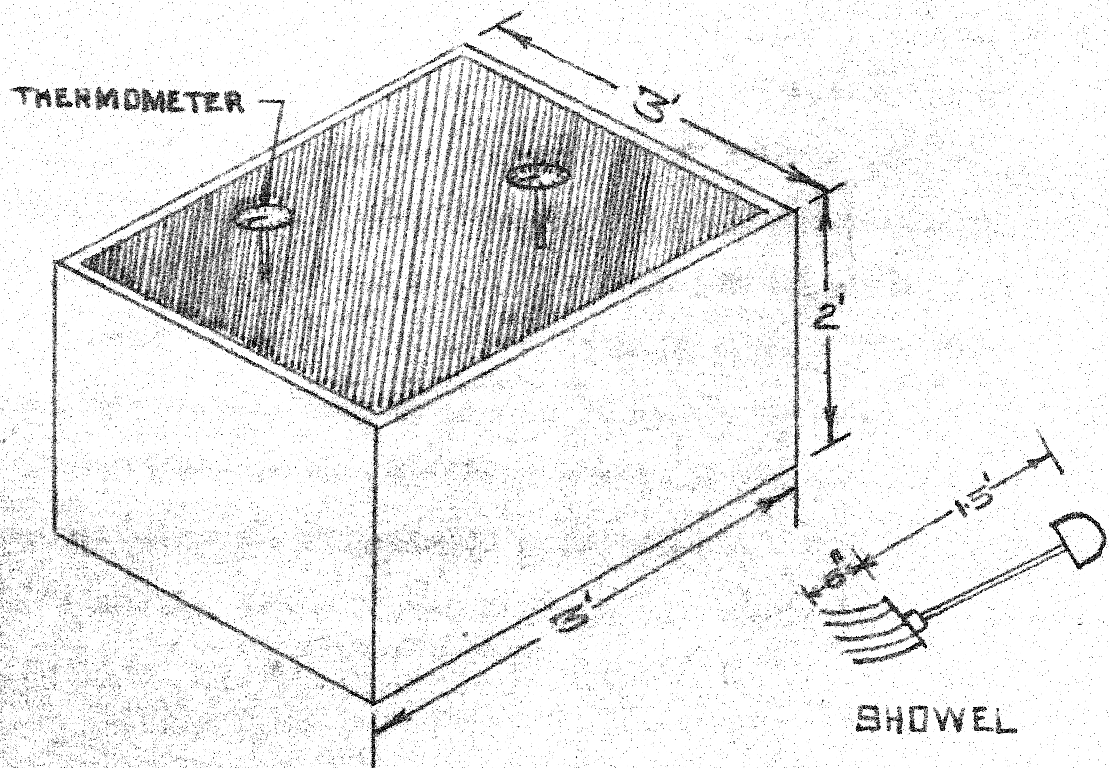
The anaerobic composting of the material was done in closed metal boxes of dimensions 3.5'x2.5'x2' (Fig. 3). The boxes had opening on one wider side and this was covered with a cement asbestoes sheet cut exactly into the size. Six holes of 2.5" diameter were drilled in the asbestoes sheets to facilitate the samplings for analysis purposes. These asbestoes sheets were well fixed to the sides of the metal boxes using angles and bolts so as to maintain perfect anaerobic conditions.

For recording the temperatures developed in the process, special thermometers (SOILTEST thermometers) were used. These thermometers had a graduated metal disc with a pointer fitted. The sensitive metallic needle (0.2" dia. 10" long) connected to the dial was inserted into the sample for recording the temperatures. These thermometers were inserted two in number in each of the compost box to know the average change in temperatures. Again, as the length of the metal needle was 10" it could approximately reach the middle depth of the samples.

Out of the six sampling holes in the asbestoes covering sheets two were fitted with rubber corks having holes for inserting thermometers, while the others were fitted with ordinary rubber corks.



ANAEROBIC COMPOSTING UNIT



AEROBIC COMPOSTING UNIT

FIG-3

The sampling was done using a sampler shown in Fig. 3. This was a metal tube $1\frac{1}{2}$" internal diameter and $2\frac{1}{2}$' long. The bottom of the pipe was sharpened to form a cutting edge at the outer side of the pipe. Handle had been welded to the top of it to facilitate insertion and taking out from the stack. The outer surface of the pipe was graduated to know the depth of insertion of the sampler into the stack.

3.4.2 Aerobic Composting :

The aerobic composting of the materials was done in open wooden boxes of dimensions 3'x3'x2'. The boxes were well warnished to prevent decaying of the wood. Four holes were driven in the bottom of the boxes to drain off the extra water retained at the bottom. This step was taken to see that no anaerobic conditions develop at the bottom.

To keep the whole material free from insects, flies and also other stray animals, the open side was covered with wire mesh and arrangements were done to fix the mesh properly.

3.5 Operation of the Process :

3.5.1 Anaerobic Composting :

The materials were mixed well in the said proportions using a metallic shovel. Sufficient amount of water was added to raise the moisture content of the samples ~~xx~~ above 85%. To have perfect insulation of the materials in the compost boxes, they were filled on all sides with a 3" thick bed of sawdust and earth mixed well in equal proportions. Now the materials were dumped with care into the boxes by intermittently compacting the surface with a metal plate to avoid possible air gaps. Then the top was covered with a asbestoes sheet and the gaps left on the edges were filled with a thick paste of putting. Thus, all possible carem was taken to ensure complete

anaerobic conditions.

The samples were drawn out and were analyzed for different parameters at intervals one week.

3.5.2 Aerobic Composting :

The materials were mixed in the same above ratios and were poured to the respective composting boxes. Care was taken to see that the depth of the material in any of the boxes did not exceed 1.5'. This step was taken to prevent the development of possible anaerobic condition at the bottom. The materials was overturned every day with the help of the shovel. Samples were taken out every alternate day for analysis in the laboratory. Sufficeint calculated quantity of water was sprinkled over the material to keep the moisture content between 50 and 60% throughout the experiment.

4 EXPERIMENTS AND RESULTS

To analyse the samples both in aerobic and anaerobic decompositions experiments were conducted in the laboratory for the following parameters.

1. Moisture content.
2. Percentage total nitrogen.
3. Percentage carbon.
4. pH
5. Percentage phosphorous.
6. Percentage Nitrate Nitrogen
7. B.O.D.

The details of the experimental proceedures are given in the following sections.

4.1 Moisture content;

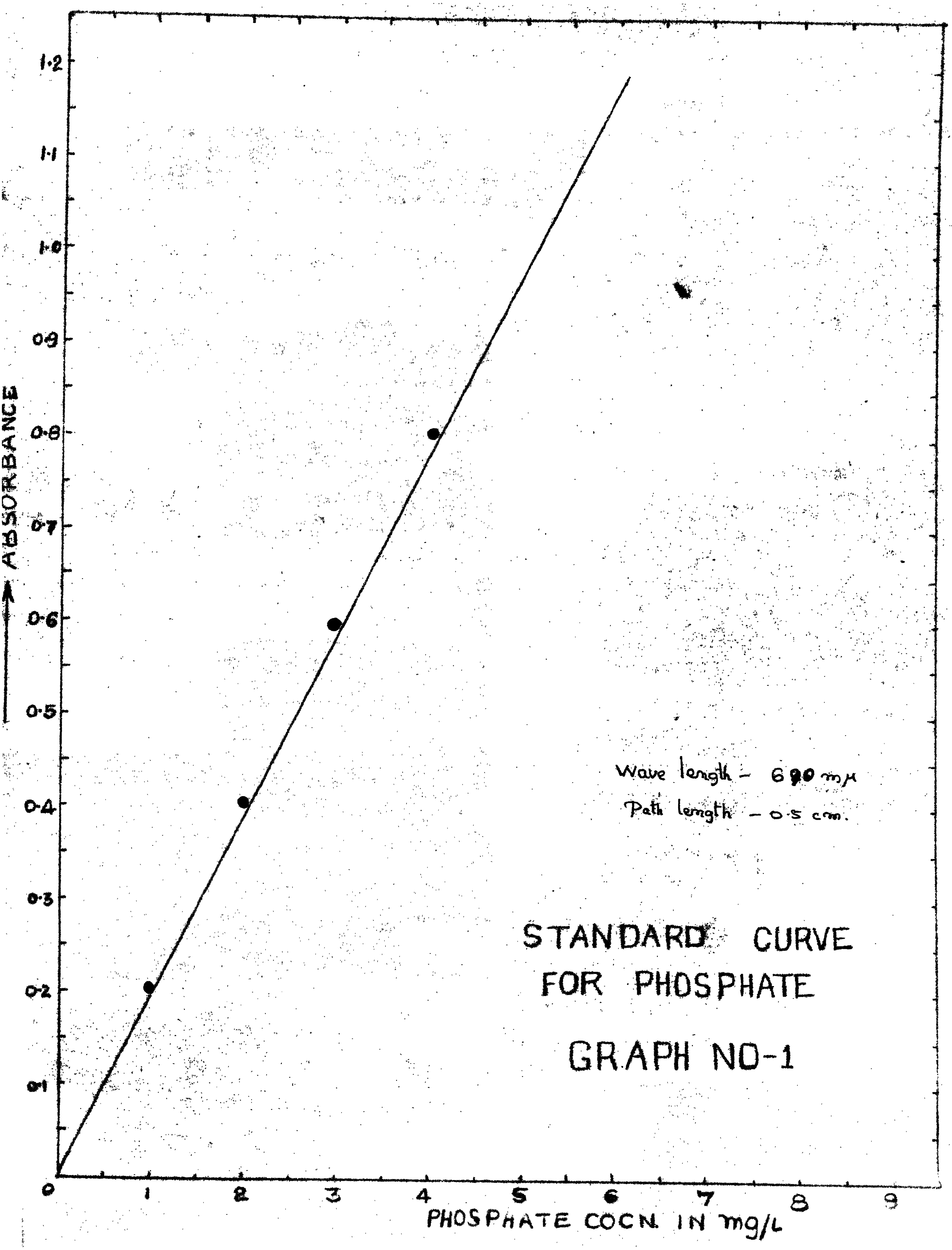
Ten grms of the sample was placed in a pan the weight of which was determined previously, the pan and the contents were then weighed, placed in a drying oven, at about 103°C for about two hours and weighed again. The percentage moisture content was calculated after correcting for the weight of the pan as

$$= \frac{\text{Original weight} - \text{Final weight}}{\text{Original weight}} \times 100$$

4.2 Percentage carbon: (dry basis)

The total amount of mineral matter usually called ash is determined by igniting a known weight of dry sample in a muffle furnace for 3 hours at 600°C to drive off all combustible organic matter and again weighing after cooling. The percentage of ash on a dry basis is then

$$\frac{\text{Dry weight before ignition} - \text{weight after ignition}}{\text{Dry weight before ignition}}$$


ABSORBANCE
1·2
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
1
2
3
4
5
6
7
8
9
PHOSPHATE COCN. IN mg/L
Wave length - 690 mμ
Path length - 0·5 cm.
STANDARD CURVE
FOR PHOSPHATE
GRAPH NO-1

The determination of the carbon-nitrogen ratio which is so important in regard to nitrogen conservation and for estimating the quality of the finished product, is more of a problem because ~~of~~ the quantitative analysis of carbon is difficult and time consuming and also expensive. It has been sugested in a New-zeland report (19) that for composting work the percentage carbon can be estimated satisfactorily from the percentage of ash. The emperical equation relating carbon and percentage ash is as follows

$$\% \text{ Carbon} = \frac{100 - \text{percentage ash}}{1.8}$$

4.3 Percentage total kjeldhal nitrogen (dry basis) :

Total kjeldhal nitrogen includes ammonia and organic nitrogen but not nitrite or nitrate nitrogen. The following procedures were adopted in calculating the total nitrogen.

Two gms of dried sample was taken and it was ground well using a porcelein mortar. This operation was continued till it was possible to keep the sample in fine uniform suspension in distilled water. The sample was then kept in suspension in one litre of ammonia free water (distilled) and tests for total kjeldhal nitrogen were ~~calculated~~ done as per the procedures given in the Standered Methods (10).

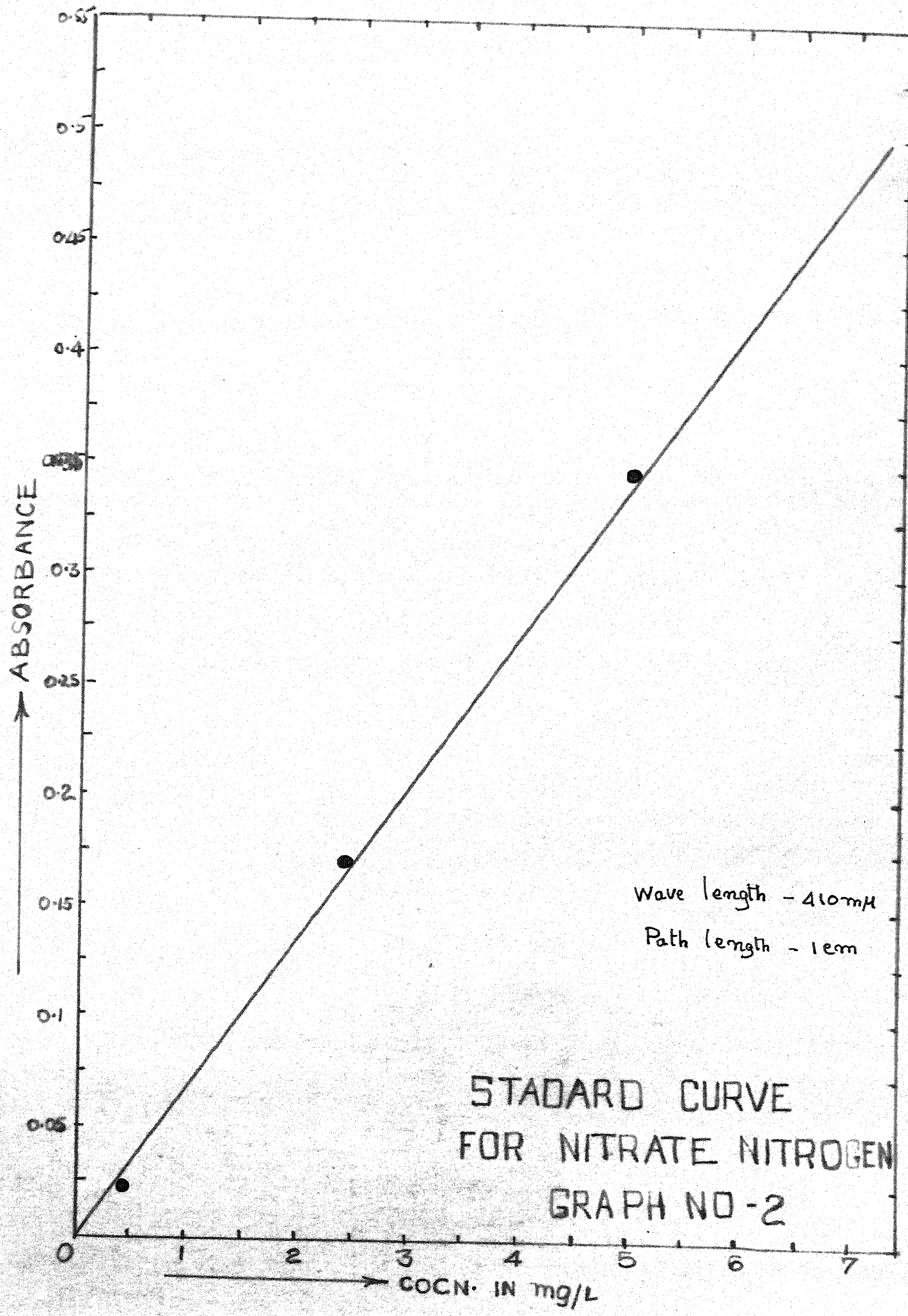
The total nitrogen was estimated in terms of Percentage by weight (dry basis).

4.4 pH :

Two gms of dried sample was ground using the porcelein mortar as mentioned in the above section. This was kept in fine uniform suspention in one litre of distilled water and the pH of this was determined using a pH meter.

4.5 Percentage phospherous as total Phosphate:

Five gms of dried sample was ground well using the porcelein mortar



0·55
0·5
0·45
0·4
0·35
0·3
0·25
0·2
0·15
0·1
0·05
0
1
2
3
4
5
6
7
ABSORBANCE
COCN· IN mg/L
Wave length - 410 mμ
Path length - 1cm
STADARD CURVE
FOR NITRATE NITROGEN
GRAPH NO - 2

as mentioned in the previous section. This sample was kept in a very fine suspention in one litre of distilled water and the total phosphate content was determined according to the procedures given in the standard methods. (Ammonium molibdate method)

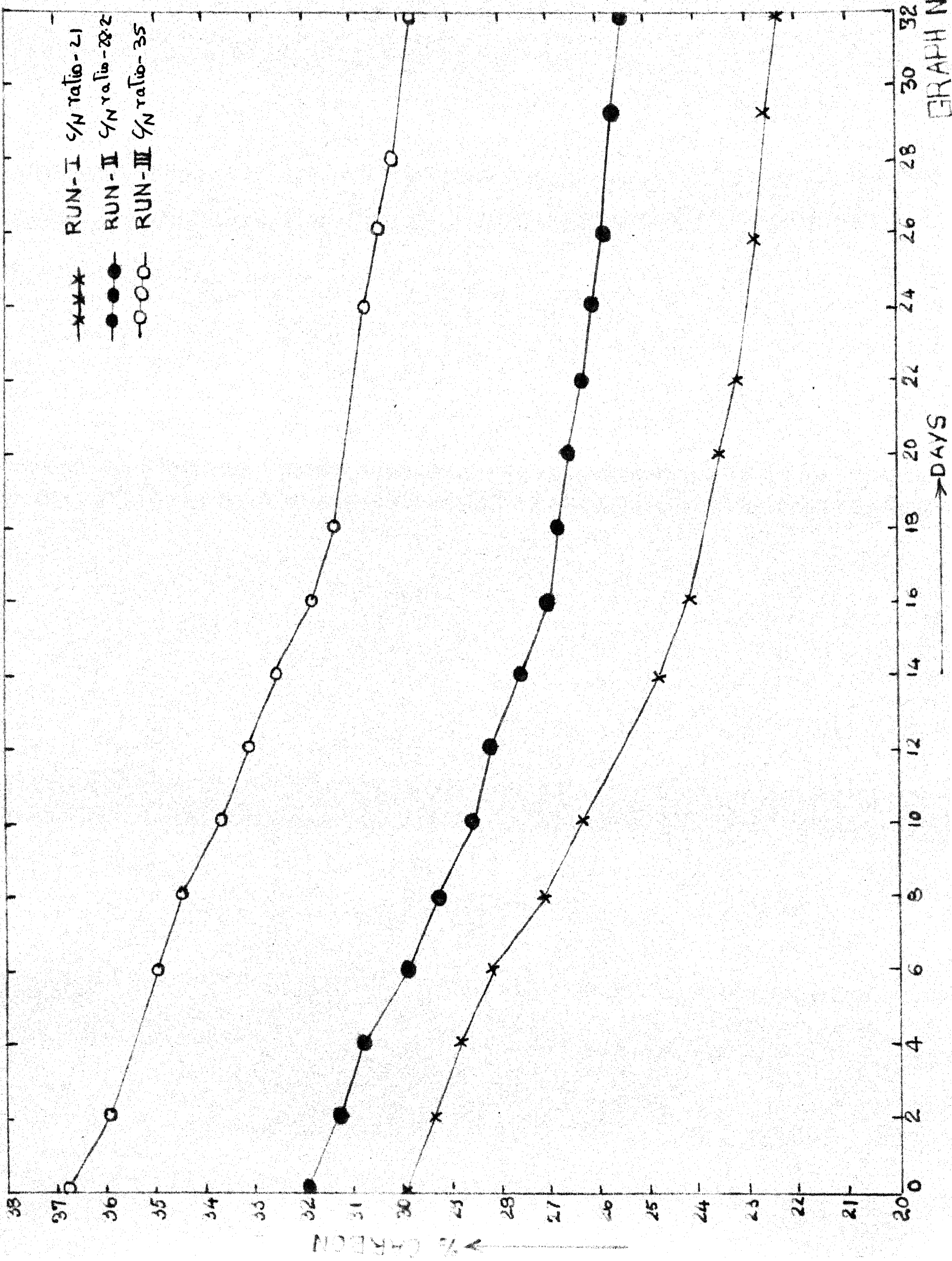
4.6 Percentage nitrate nitrogen:

Five gms of well dried sample was ground well using the porcelein mortar. The sample was kept in a very fine uniform suspention in one litre of distilled water and the nitrate nitrogen content was determined according to the procedures given in the Standard methods (Brucine methods)

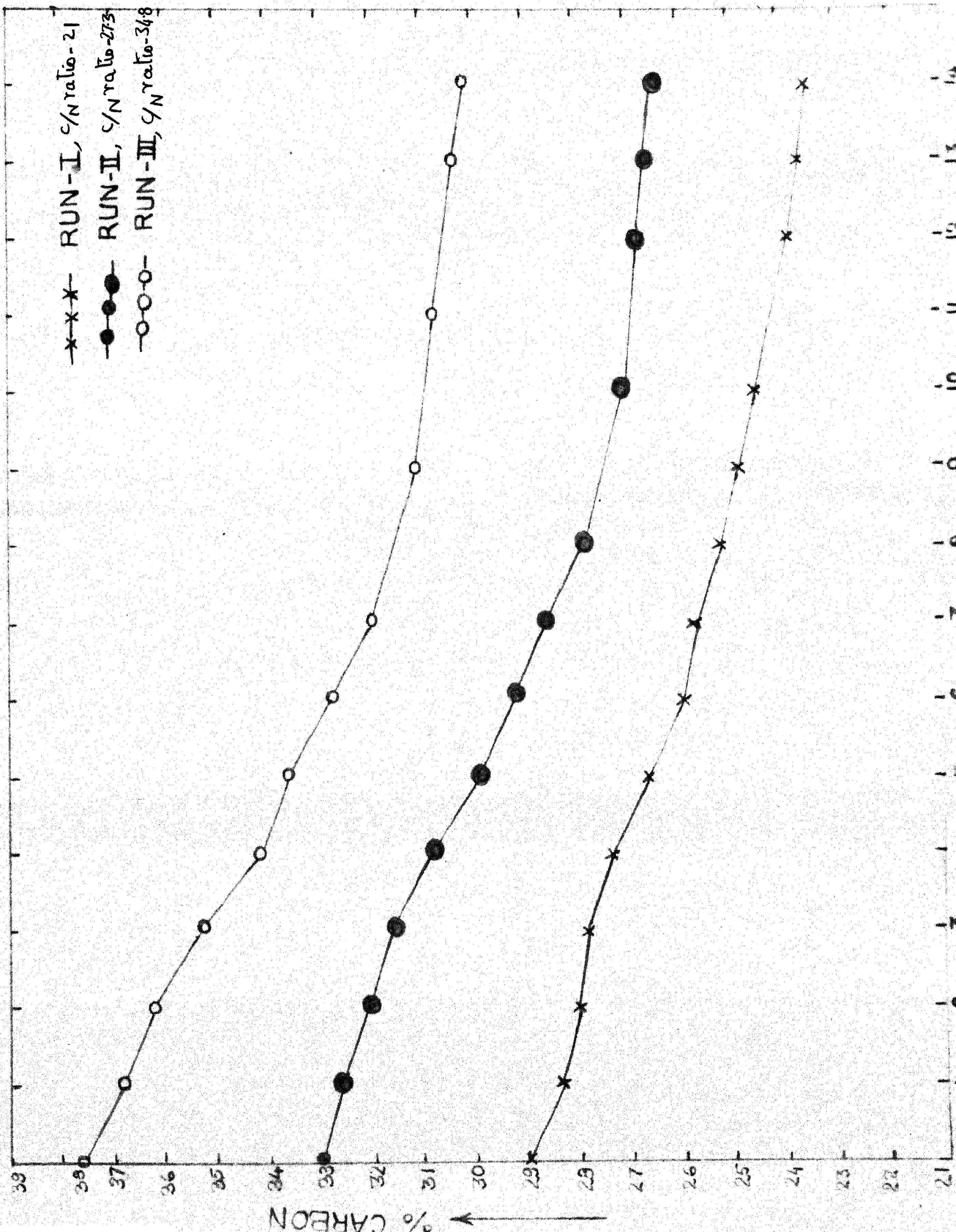
4.7 B.O.D.

Hundred mgs of well dried sample was ground well and this was kept in a very fine suspention in one litre of distilled water. The five day B.O.D. of this sample was determined according to the procedures givent in the Standard methods. The B.O.D. was calculated in terms of mg/gm.

AEROBIC COMPOSTING % CARBON VS TIME

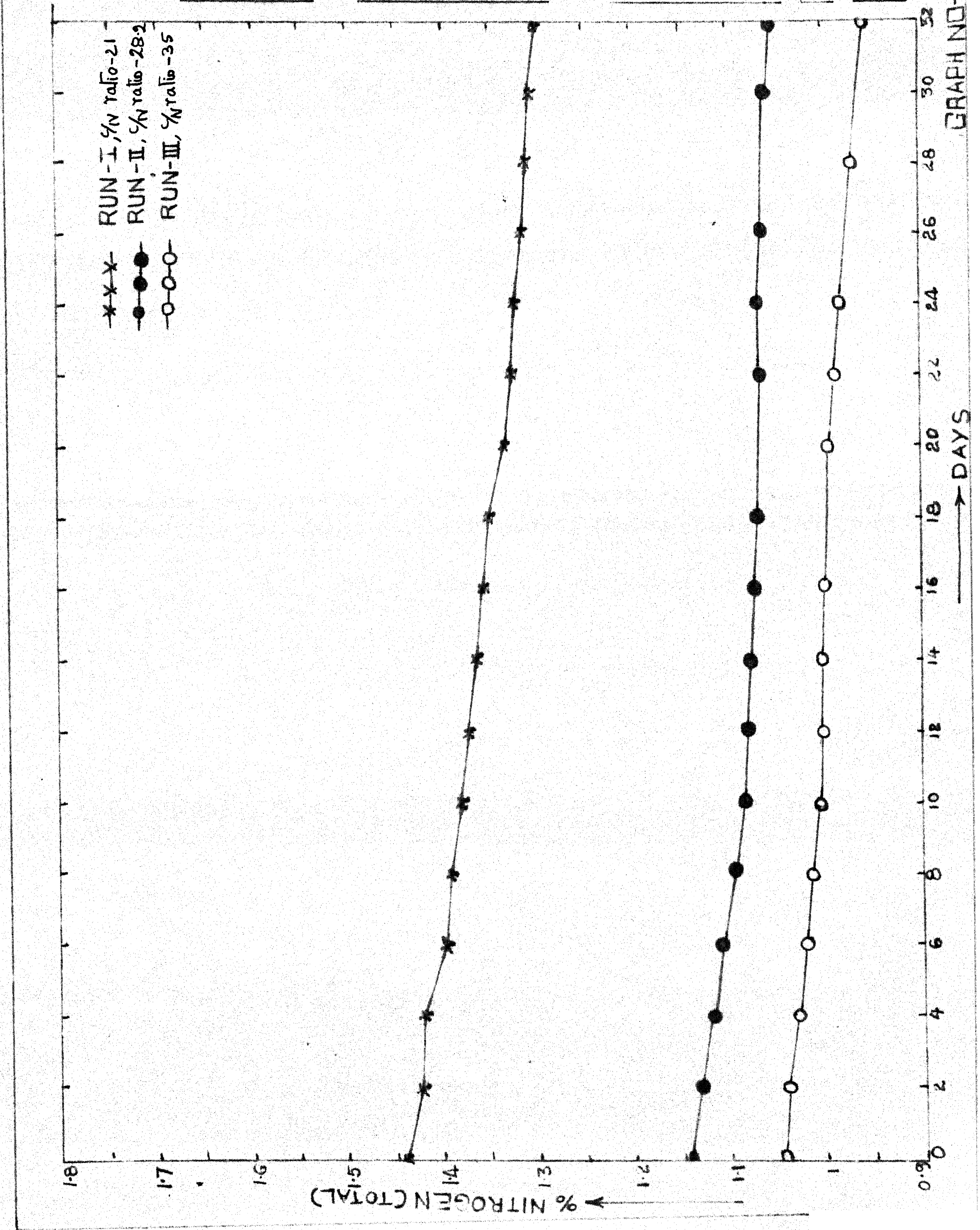


ANAEROBIC COMPOSTING % CARBON VS TIME



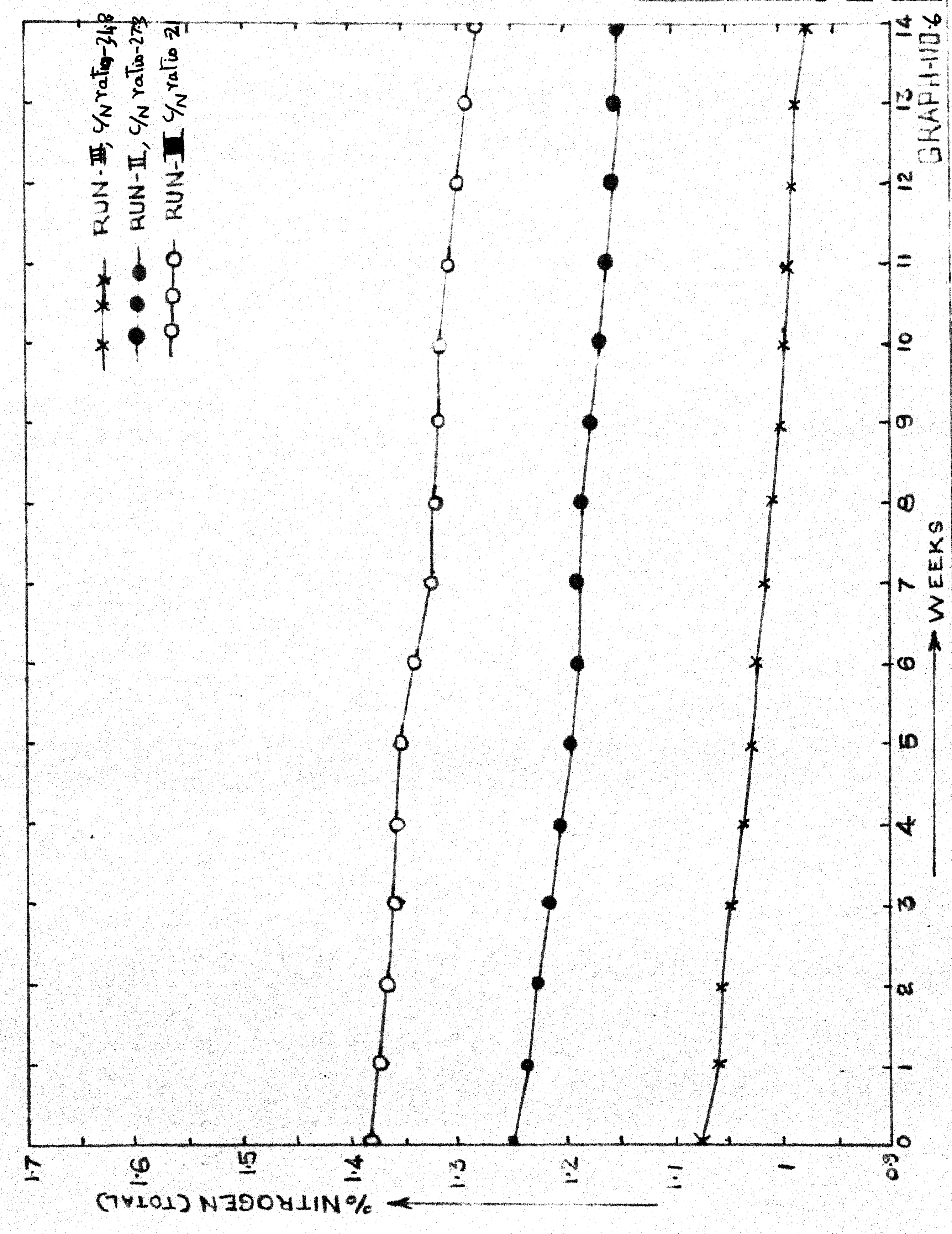
GRAPH NO. 4

AEROBIC COMPOSTING %NITROGEN VS TIME



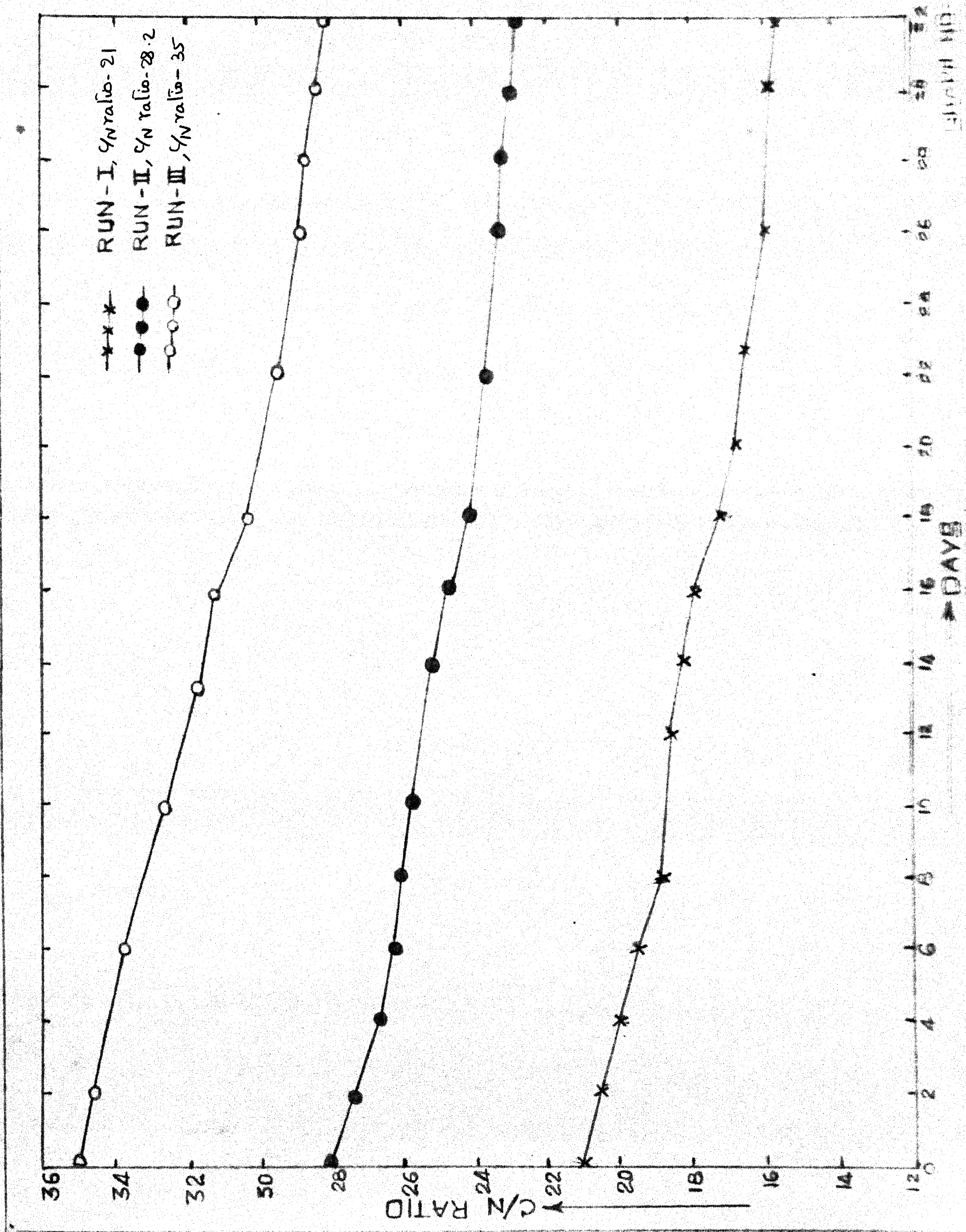
GRAPH NO-5

ANAEROBIC COMPOSTING % NITROGEN VS TIME

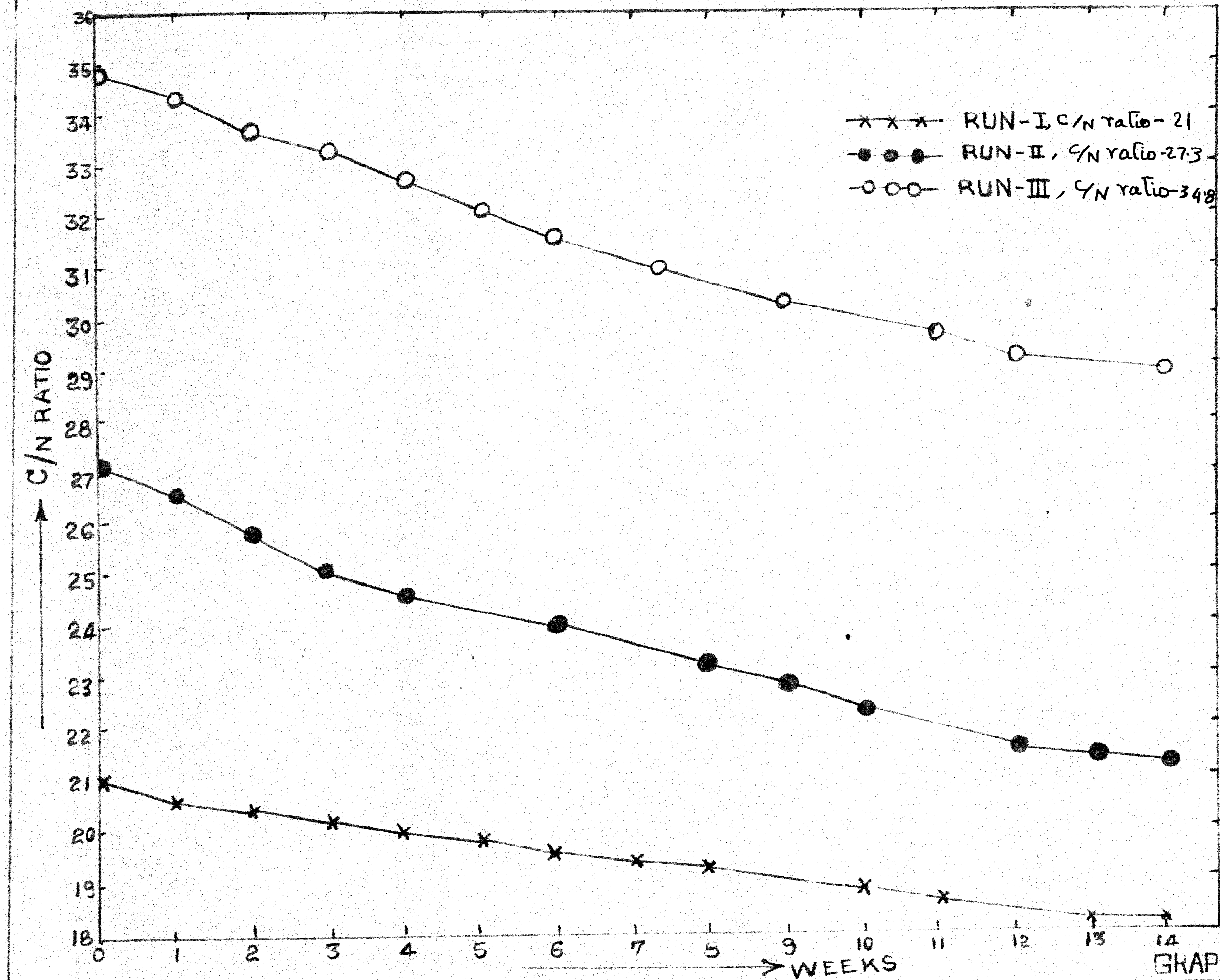


AEROBIC COMPOSTING C/N RATIO VS TIME

GRAPH NO. 7



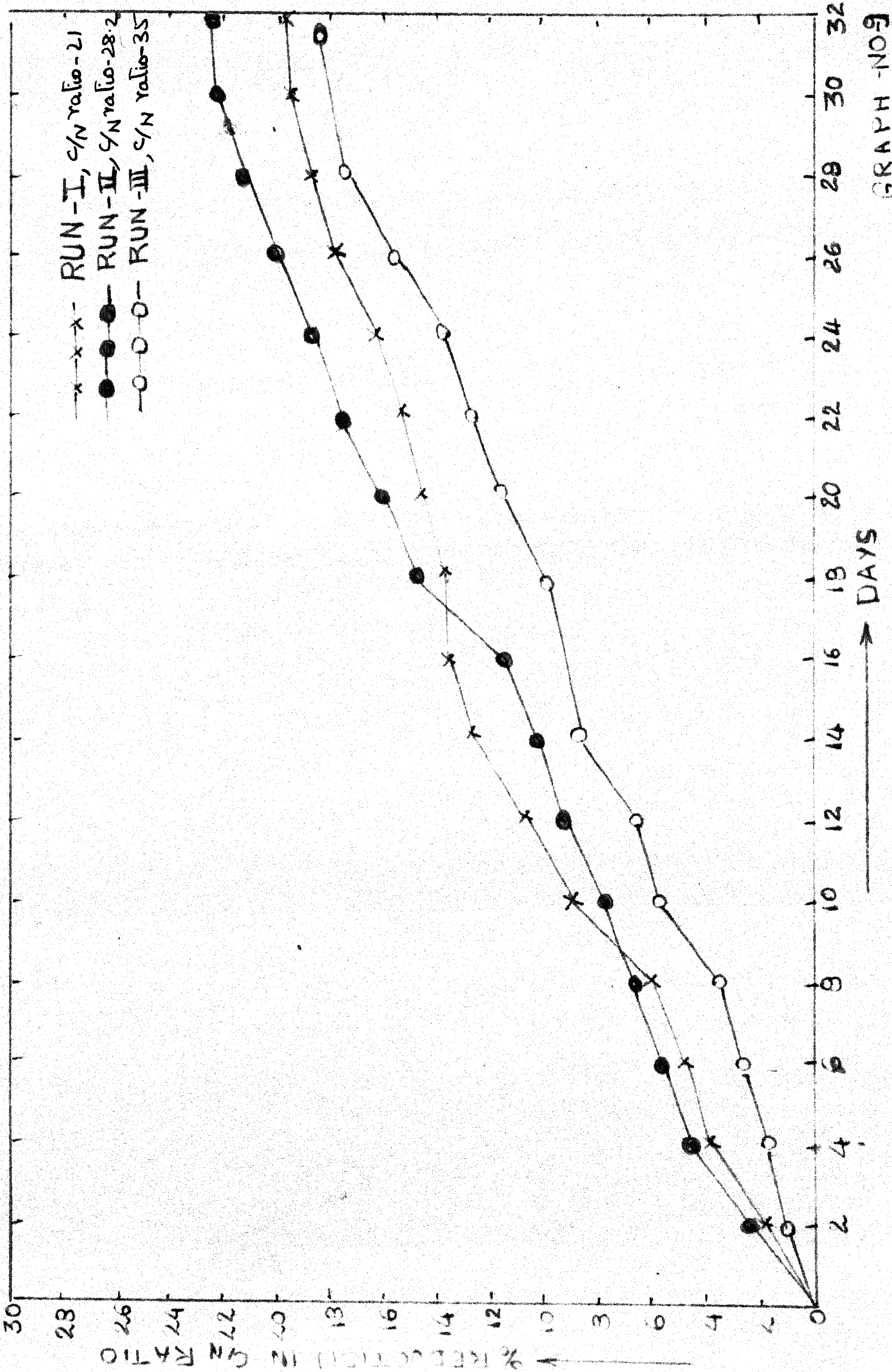
ANAEROBIC COMPOSTING C/N RATIO VS TIME



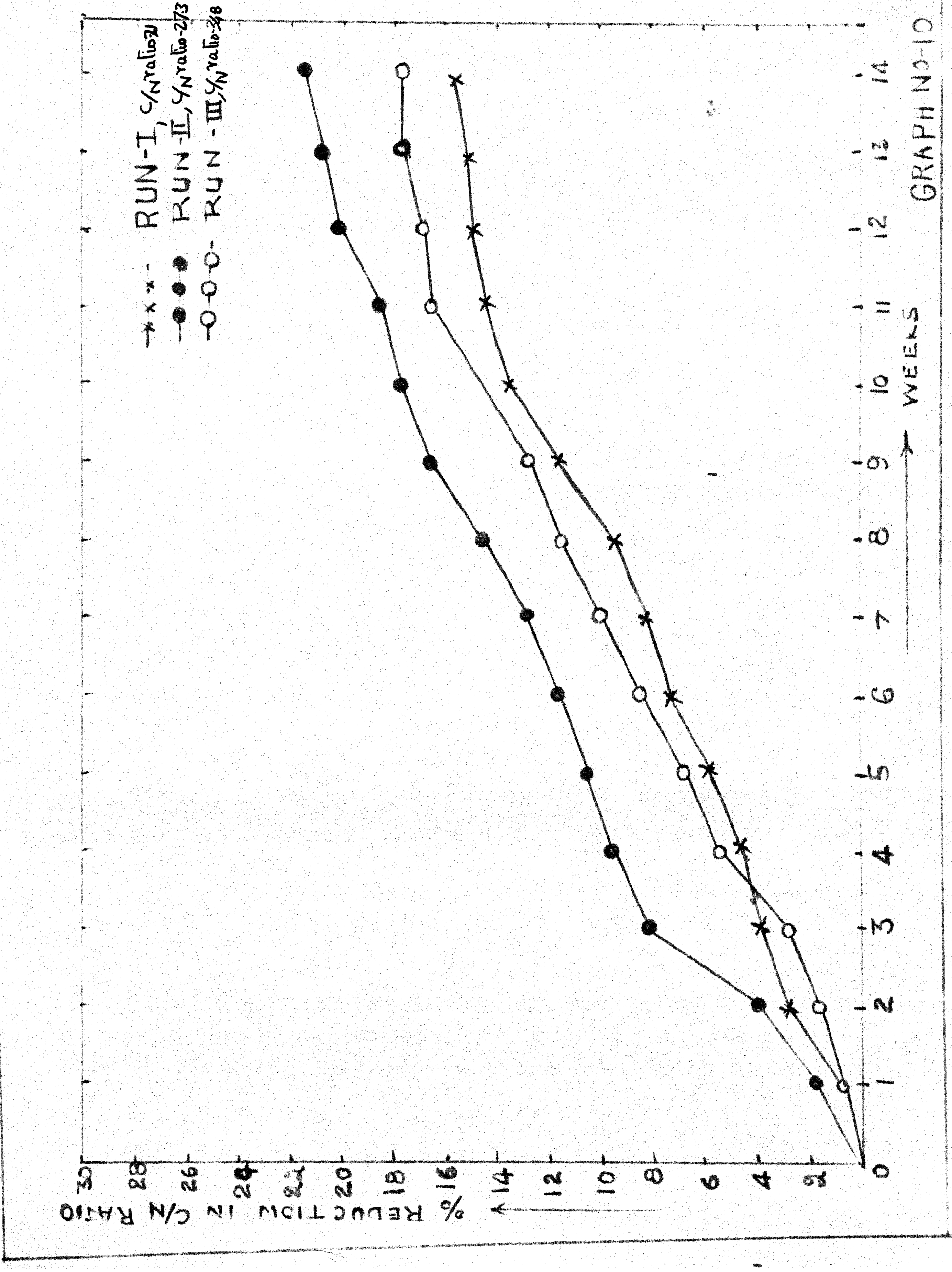
GRAPH-NO-8

AEROBIC COMPOSTING

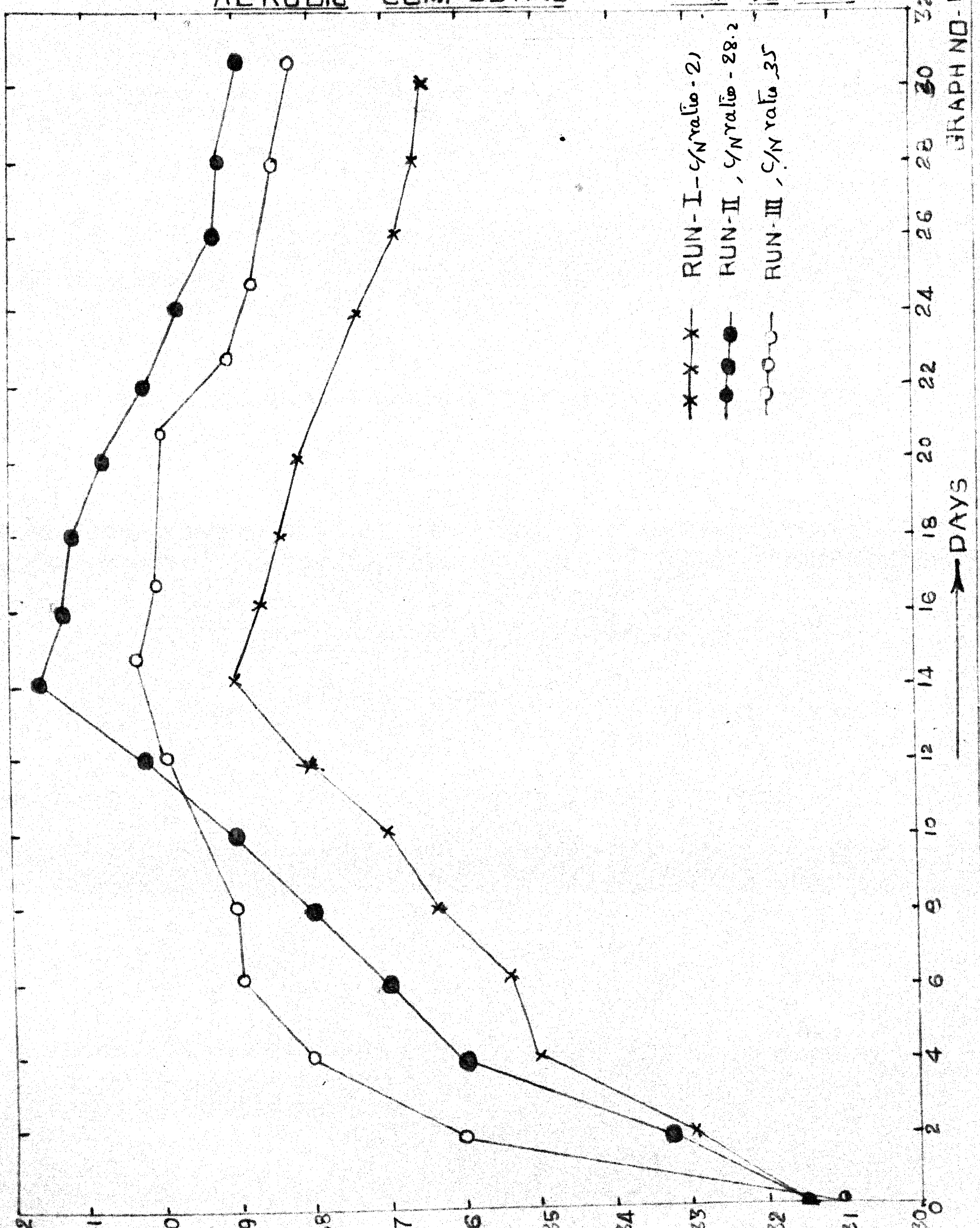
PERCENT REDUCTION IN C/N RATIO Vs TIME



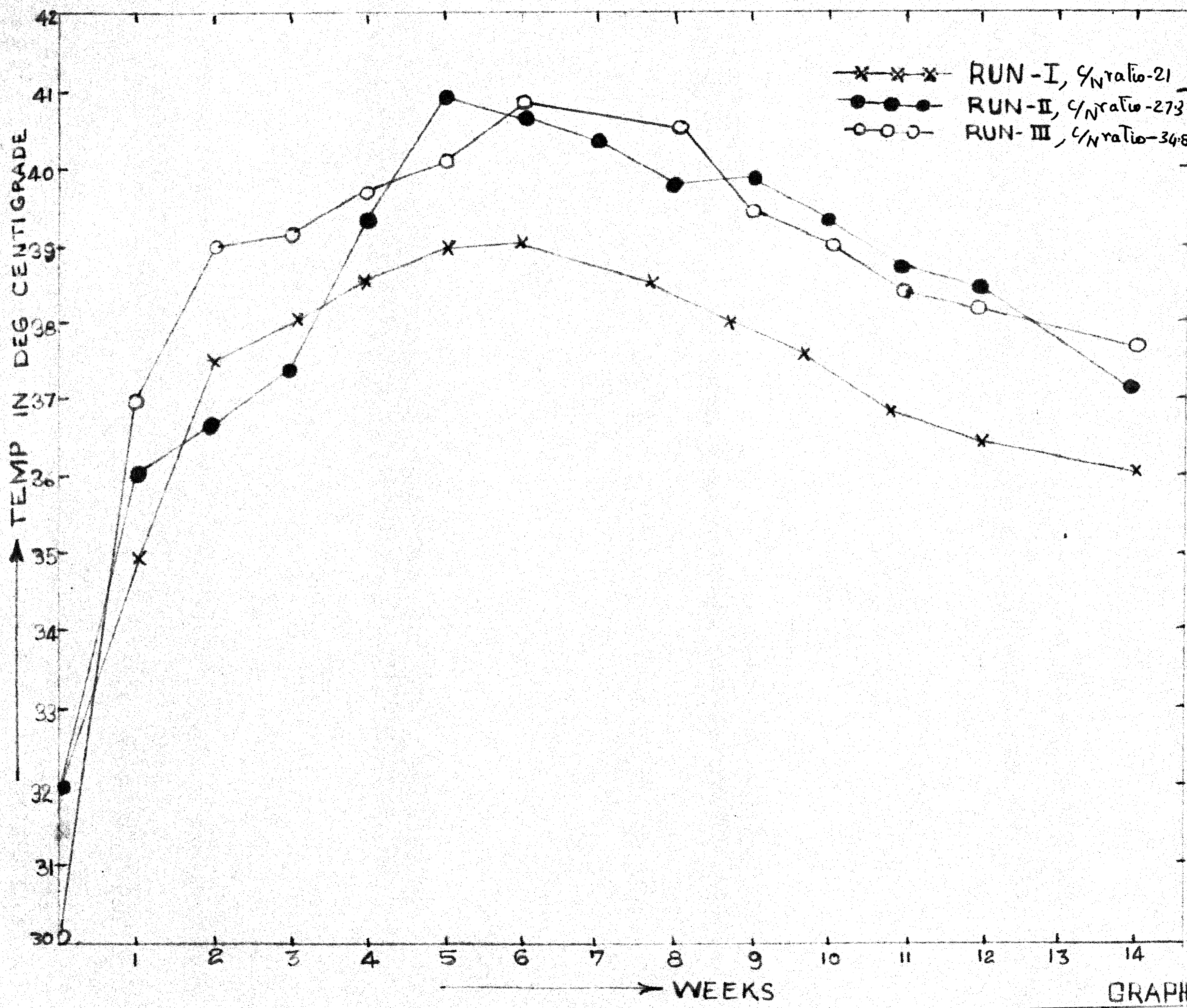
ANAEROBIC COMPOSTING
PERCENT REDUCTION IN C/N RATIO VS TIME



AEROBIC COMPOSTING TEMP VS TIME



ANAEROBIC COMPOSTING TEMP VS TIME



GRAPH NO-12

Table 1

	Total carbon	Total nitrogen	Moisture content
Spent bark	38%	----	27%
Fleshings from hides	4.7%	6.78%	96%

Note- Both carbon and nitrogen are percentages weights on dry basis

Table No-2

Change Of pH With Time.

Aerobic Composting.

Time in Days	Run-I	Run-II	Run-III
Zero	6.9	6.3	6.2
2	6.7	6.2	6.1
[illegible]	6.6	5.9	6.0
6	6.4	6.0	5.9
8	6.5	6.0	6.0
10	—	6.2	6.0
12	6.5	—	6.2
14	6.6	6.4	6.3
16	6.7	6.6	6.4
18	6.9	6.7	6.4
20	6.9	6.8	6.4
22	7.0	6.8	6.5
24	7.1	7.0	6.6
26	7.2	7.0	6.7
28	7.3	7.1	6.8
30	7.3	7.2	6.8
32	7.3	7.2	7.0

Table No-3

Change of pH with Time

Anaerobic Composting.

Time in Weeks	Run-I	Run-II	Run-III
Zero	6.9	6.4	6.0
1	6.7	6.3	5.8
2	6.4	6.0	5.6
3	6.1	5.8	5.5
4	6.0	5.9	5.5
5	6.2	6.2	5.7
6	6.2	6.6	5.8
7	6.3	6.8	6.0
8	6.4	7.2	6.2
9	6.7	7.3	6.5
10	6.8	7.6	6.8
11	6.9	7.7	7.2
12	7.0	7.7	7.2
13	7.2	7.7	7.4
14	7.3	7.8	7.5

Table 4

B.O.D. Results

Aerobic Composting.

	Run-I	Run-II	Run-III
Initial	74	73	70
Final	48	42	40

All the values are in mg/gm

Table 5

B.O.D. Results

Anaerobic Composting.

	Run-I	Run-II	Run-III
Initial	76	73	70
Final	49	42	43

All the values are in mg/gm

Table 6.

Percent phospherous as Total phosphate of final compost (~~perce~~ dry wt basis)

	Run-I	Run-II	Run-III
Aerobic Composting	0.13	0.12	0.12
Anaerobic Composting	0.11	0.12	0.10

Table 7

Percent nitrate nitrogen in final compost

(dry wt basis)

	Run-I	Run-II	Run-III
Aerobic Composting	0.07	0.05	0.06

5: DISCUSSION OF RESULTS

5.1 Carbon-Nitrogen Ratio

Whether it is aerobic or anaerobic decomposition, the rate of decomposition depends upon the amount of carbonaceous and nitrogenous material present. Thus many of the earlier workers have emphasised the importance of evaluating the course of decomposition by a careful check on the carbon-nitrogen ratio which means the amount of total carbon to total nitrogen. However it is important and essential to realise that all the total carbon may not be available for bacterial decomposition such as the carbon from lignins, cellulose or compounds that are resistant to biological decomposition. Generally speaking carbon compounds are used as a sourse of energy, and nitrogen for building cell structure. The carbon-nitrogen ratio of 20,where both carbon and nitrogen are in biologically available quantities seems to have been widely accepted as the upper limit at which the micro-organisms will not "rob" the nitrogen from the soil. This ratio of 20, does not apply for composting according to Gottas (3) The ratio recommended by many research worker ranges from 26 to 31, (3, 23, 24, 25). Actually the living organisms use about 30 parts of carbon for one part of nitrogen. Studies in the University of California (25) indicated the use of initial carbon-nitrogen ratio of 30 to 35 as optimum. Based on this information carbon-nitrogen ratios were adjusted initially between 20 to 36. The final ratios obtained have ranged between 17 to 28. This indicates that the final

compost material will not rob soil nitrogen when applied as a manure. One observation to be made on the carbon-nitrogen ratios observed in these experiments, the reduction in the ratios was comparatively less in the tannery waste material composting as compared to conventional night soil or refuse composting. Most probably this is due to the quantities of unavailable carbon in the form of cellulose that is in the spent bark. An examination of tables (4&5) indicates that the available carbon as measured by the BOD has been consumed to an extent of 67 % in aerobic and 64 % in anaerobic process supporting the view point that all the carbon is not readily available for decomposition. As can be expected the aerobic process was more efficient in oxidising the available carbon.

A carbon-nitrogen ratio of about 28 or 30 seems to be better suited, since rate of decomposition is slightly faster compared to the other two mixtures (vide graphs 9&10). This in fact supports the view point of Acharya(13) and Gottas (3)

5.2 Percent Nitrogen:

Looking at the graphs 5&6 we can observe that there is decrease of total nitrogen content in all the samples of both aerobic and anaerobic decompositions. In anaerobic decomposition the decrease is most probably due to the escape of nitrogen as ammonia even though a little is used up by the micro-organisms for the building up of cells (3).

It can also be seen from the graphs (6) that there is no

appreciable decrease in the nitrogen up to the 5th. week in the anaerobic decomposition. After this period the pH which has been around 5.5 increased to above 7. Concurrent with this increase, loss of nitrogen is noted indicating a possibility that ammonia might be escaping. This is also in confirmity of the statement by Scott and Gottas (3).

In the aerobic composting process there is practically no loss of nitrogen as can be seen from the Graph [redacted] (5). The little loss in total nitrogen is compensated in the production of nitrate which is not included in the total nitrogen estimation (Standard Methods). The presence of nitrate in the final compost makes it a good fertilizer.

5.3 Temperature:

The rise in temperatures were not upto the expected range, both in the case of aerobic and anaerobic decompositions. The maximum temperatures recorded were 42°C aerobic and 41°C in the anaerobic samples. This may be due to the following reasons.

(a) A great deal of energy is released in the form of heat in the oxidation of carbon to carbon dioxide in the case of aerobic decomposition. In the case of anaerobic fermentation the energy of the carbon is in the methane released. If the methane is burnt to carbon dioxide large amount of heat are evolved. As explained earlier the decomposition rate in both aerobic and anaerobic decompositions was comparatively lower.

Thus the energies liberated in the processes in the form of heat were also low

(b) There may be greater loss of heat from the larger surface area exposed, compared to the volume of the sample. This was observed and reported also in the composting experiments conducted by Ghate (19) and Saxena (26) in Roorkee University.

According to Gottas (3) more heat energy is liberated in aerobic than in anaerobic decomposition. This also was observed in the experiments conducted. (wide graphs 11&12)

The aerobic samples showed an increase in temperature up to the mesophilic range with in three days and there after this persisted upto the 18th. day, after which the temperature dropped down. This clearly indicates that the high rate of conversion of carbon to carbon dioxide has taken place.

The anaerobic samples showed rise in temperature after 3 rd. week and this slowly dropped down after 9 th. week showing that active decomposition has taken place between 3 rd. and 9 th. weeks.

5.4 pH:

The pH has sharply decreased from 8 to 5.0 in the first four weeks in the case of anaerobic decomposition, which is probably due to the large amounts of acids produced during decomposition. The pH increased gradually after the 5th. week indicating the production of ammonia. (Table-3)

On the contrary there were little decrease in pH in the first four days in the aerobic samples. pH gradually increased after this period confirming the statement made by Gottas (3) that when the initial pH is in between 6.0 and 7.0 the pH of the composting material will usually decrease a little during the first two to three days in aerobic composting owing to the formation of some acids. After this period the pH will rise and level off at between 8.0 and 9.0 towards the end of the process.

According to Gottas (3) the control of pH is seldom a problem requiring attention if the material is kept aerobic. Since the optimum pH for most of the organisms is around 6.5 and 7.5 it would probably be benificial , if the pH could be mainted in that range. It is however reccommended that if tthe pH falls below 4.0 the material should be strongly buffered, As in both aerobic and anaerobic decompositions the pH was well above 5.5 the problem of controlling pH does not arise.

The tannery turning out about 100 hides per day is disposing about 1.9 tons of flesh and about 12 tons of spent bark every day. Thus by composting the two material in a carbon-nitrogen ratio 28 no waste material will be left untreated.

Willcox, Comber (10) stated that a good manure is one which supplies all the deficient elements required for the growth of plants. It contains about 2.0% nitrogen and about 1.5% phospherous (both on dry weight basis) . As the phospherous contents in the samples were around 0.13% and nitrogen contents were around 1.2%, it could probably serve as a good fertilizer.

CONCLUSIONS

From the studies described in this work the following conclusions may be drawn.

1. The solid wastes from a vegetable tannery like spent bark and other vegetable matter and fleshings from the hides can be mixed and composted by either aerobic or anaerobic method.
2. Initial control of carbon,-nitrogen ratio around 28 seems to be more efficient irrespective of aerobic or anaerobic process.
3. For a vegetable tannery producing about 100 hides per day, like the one investigated in this study, the waste materials can be mixed in the propotions of 1:6 (flesh to bark) thus leaving no material untreated.
4. In both aerobic and anaerobic processes there seems to be no necessity of controlling the pH of the total heap, since it did not go below pH 4.0 in any of the samples.
5. The composted material can be used as a fertiliser, since the final carbon-nitrogen ratio are around 21 in both cases (where the initial carbon-nitrogen ratio was 28) and it contains about 1.2% of nitrogen and about 0.13% of phospherous by dry weight.

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